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Feasibility of MHealth Interventions towards Promoting HIV Self-testing Uptake in Sub-Saharan Africa: A Systematic Review of Literature

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ABSTRACT
Background: HIV self-testing (HIVST) with mobile health technology (mHealth) support is the use of mobile phone-based interventions to complement HIVST in order to improve its efficiency and uptake. Existing reviews leaves a gap in the evidence that summarizes efforts on the feasibility of mHealth to promote HIVST uptake within Sub-Saharan Africa (SSA).
Objective: This study synthesized existing research on the feasibility of mobile health technology (mHealth) aimed at promoting HIV self-testing (HIVST) uptake within SSA using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.
Result: Eleven studies met the inclusion criteria and were narratively synthesized, 63% of which were observational studies while 37% were randomized control trials. Mobile applications, SMS or a combination of mHealth strategies were mostly used to promote HIVST uptake. Most studies were carried out in South Africa (54%), and in the general population (54%). Feasibility metrics were inconsistently reported across studies because its definitions varied, nonetheless most studies reported one or more feasibility metrics and HIVST uptake was the most common way (81%) of assessing feasibility.
SMS-based interventions significantly increased HIVST uptake among hard-to-reach populations and were effective for reporting testing outcomes. Mobile applications guided participants through testing, result interpretation, and self-reporting HIVST results, and most studies reported high HIVST uptake (89.0%–100%). Compared to HIVST alone, call-based intervention enhanced HIVST uptake and linkage to care or prevention ($p = 0.021$). Most studies found combined mHealth interventions highly feasible (78.9%–99.2%).
Conclusion: Feasibility was variable between the diverse mHealth supports used to promote HIVST uptake. While findings pave the way for greater use of mHealth supported HIVST, future research should consider using rigorous research designs and focus on populations disproportionately affected by HIV within diverse SSA regions to ensure broad applicability. Feasibility measures should also be standardized for uniform reporting across studies.

KEYWORDS: Feasibility, HIV, MHealth, Sub-Saharan Africa, Self-testing.

I. INTRODUCTION

Globally, as of the end of 2021, approximately 38.4 million individuals were living with the Human Immunodeficiency Virus (HIV), with two-thirds (25.6 million) of them disproportionately within Sub-Saharan Africa (SSA) (1,2). Although testing for HIV is a crucial first step to engaging HIV treatment by infected persons (3,4), one-fifth of those aged 15–64 in SSA remain undiagnosed despite the spread of HIV testing services (HTS) (5). HIV self-testing (HIVST) is a novel method for individuals to screen for HIV at their convenience using blood or oral fluid rapid diagnostic tests (6,7). Compared to conventional facility-based HIV testing, HIVST has the potential to address barriers to existing HIV testing uptake such as stigma and confidentiality concerns by serving as an entry point for HIV testing and thereby increasing access to HIV testing for populations that are hard to reach (8–11). Given the potential of HIVST, the World Health Organization (WHO) in 2016 endorsed the utilization of HIVST as an alternative to conventional facility-based testing (12–14).

Although studies have indicated that HIVST is generally well-received and feasible among high-risk groups who may not otherwise test (15,16), the reported uptake of HIVST is quite variable within different populations (17,18). Factors such as the independence of HIVST present challenges about users' self-efficacy in performing and interpreting the self-test results (19–21). Furthermore, since self-testing for HIV does not offer a conclusive diagnosis, individuals who get a positive self-test result are

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suddenly confronted with a significant diagnosis and lack immediate access to counseling with linkage to confirmatory testing, or care (21–24). The possibility of social harm also influences HIVST usage (23,25), and limitations exist regarding HIVST monitoring and evaluation (M&E) for program stakeholders (21).

HIV self-testing with mobile health technology (mHealth) refers to the usage of mobile phone-based interventions to support self-testers through testing, report HIVST results or facilitate linkage to care in order to scale up HIVST, improve its effectiveness and impact, and ultimately increase HIV testing uptake (21,26). Given mobile phones' popularity, ubiquitous presence, vast usage in countries with low and middle income and their multi-communication functionalities, they are particularly appropriate for providing health-related low-cost interventions (21,27). Mobile phone deliverables are also advantageous because they can be delivered or accessed within the relevant context in terms of time, ease, privacy, and interactivity, thereby providing personalized support for users (21,27,28). High mobile phone ownership also provides potential avenues for leveraging mHealth to guide participants through the testing process, provide real-time remote HIVST support and counseling, review test result images as a measure of monitoring and evaluation, follow-up, and link users to care (21,29). Conversely, among other efforts, the WHO in 2019 called for data indicating the potential of digital health tools to promote HIV self-testing (30).

MHealth integration in HIVST is emerging, and research has shown growing interest in it because of the potential to address some of the challenges associated with self-testing, which is necessary to promote HIVST uptake and crucial for an effective roll-out (26,31–32). Existing reviews of mHealth-supported HIV testing studies have largely focused on conventional HIV testing (33,34). When they were focused on HIV self-testing, they spanned a wide range of digital technology, were not restricted to mHealth (26,35–36), were limited to specific populations, such as transgender people or men who have sex with men (MSM) (36), or were non-focused within SSA (28).

While mHealth support for HIVST is expanding, there is a knowledge gap about which mHealth support approaches have been feasible to promote the uptake of HIVST in SSA. Given the need to close this gap, the researcher did a review of evidence from SSA on HIV self-testing with mHealth supports. This systematic review's objective was to synthesize evidence that summarizes existing efforts that leverage mHealth to promote HIVST uptake within sub-Saharan Africa and their feasibility, without limits on study populations or outcomes. The review has the potential to provide directions for future study and practice in this developing area.

II. METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (37) was followed for conducting this systematic review. A comprehensive search for literature that promoted HIVST uptake in SSA was conducted and the feasibility of any mHealth technology used (phone calls, short message service (SMS), mobile applications(apps)), was assessed.

A. Eligibility criteria

Given that mHealth for HIVST promotion is quite novel, we included all quantitative studies [randomized controlled trials (RCTs), quasi-experimental or observational studies] that assessed any mHealth utilized for HIV self-test, reported feasibility outcomes, and were carried out in any country in sub-Saharan Africa. Studies without a focus on HIVST or did not include or evaluate an mHealth component were excluded. Trial protocols and review articles were also not included in this review. All studies had to include a mobile health component either completely or partially in the HIVST process, whether it was for HIV self-test delivery, its administration, test result interpretation, reporting of testing outcomes, linking to care, or follow up and were excluded if the mHealth component was not directly related to promoting HIVST uptake.

B. Databases search

A systematic search of scholarly literature published in English between January 1, 2010 and March 1, 2023 was undertaken using PubMed, SCOPUS, and CINAHL. Google Scholar and the bibliographies of studies that were retrieved were also reviewed for additional relevant citations. The search strategy combined relevant search phrases and utilized a combination of terms relating to HIV, self-testing, mobile health technology, and sub-Saharan Africa.

The search strategy used for PubMed combined the following search phrases: HIV OR "human immunodeficiency virus" OR "acquired immunodeficiency syndrome") AND (self-testing* OR self-sample OR "home test*" OR "home-based test*") AND ("mobile health technology" OR mHealth OR "mobile health" OR "mobile phone*" OR "mobile devices" OR "mobile apps" OR "cell

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phones" OR "cellular phones" OR "smart phone*" OR smartphone* OR SMS* OR text* OR "text messaging") AND ("sub Saharan Africa" OR Nigeria OR Kenya OR Zimbabwe OR Zambia OR Uganda OR Ghana OR South Africa OR Botswana).

C. Data abstraction

Data was abstracted for geographical location, study design, target population, study period, sample size, type of mHealth HIVST support (mobile apps, SMS, phone call), non-mHealth add-on, study objective, intervention description, study results (feasibility and its associated metrics), author conclusion, and recommendations for research or practice (Table 1).

D. Summary measure

The summary measure used to assess HIVST with mHealth support was feasibility, which is a distinct implementation outcome and is defined as the convenience and extent of successful use of HIVST with mHealth (26,38). Metrics for feasibility include proportions of HIVST uptake, assisted testing, supervised testing, response to mHealth, error in mHealth, or retention on mHealth.

E. Risk of bias

The quality of clinical trials and observational studies was evaluated using the Cochrane Risk of Bias Tool (39). For cohort studies, the Newcastle-Ottawa Scale (40) was utilized while an adapted version of the Newcastle Ottawa scale (41) was used for cross-sectional studies.

III. RESULTS

Of the 202 studies that were initially identified, 37 records were evaluated for eligibility, and 11 articles **met** the specified inclusion criteria, making them a part of this review (Figure 1).

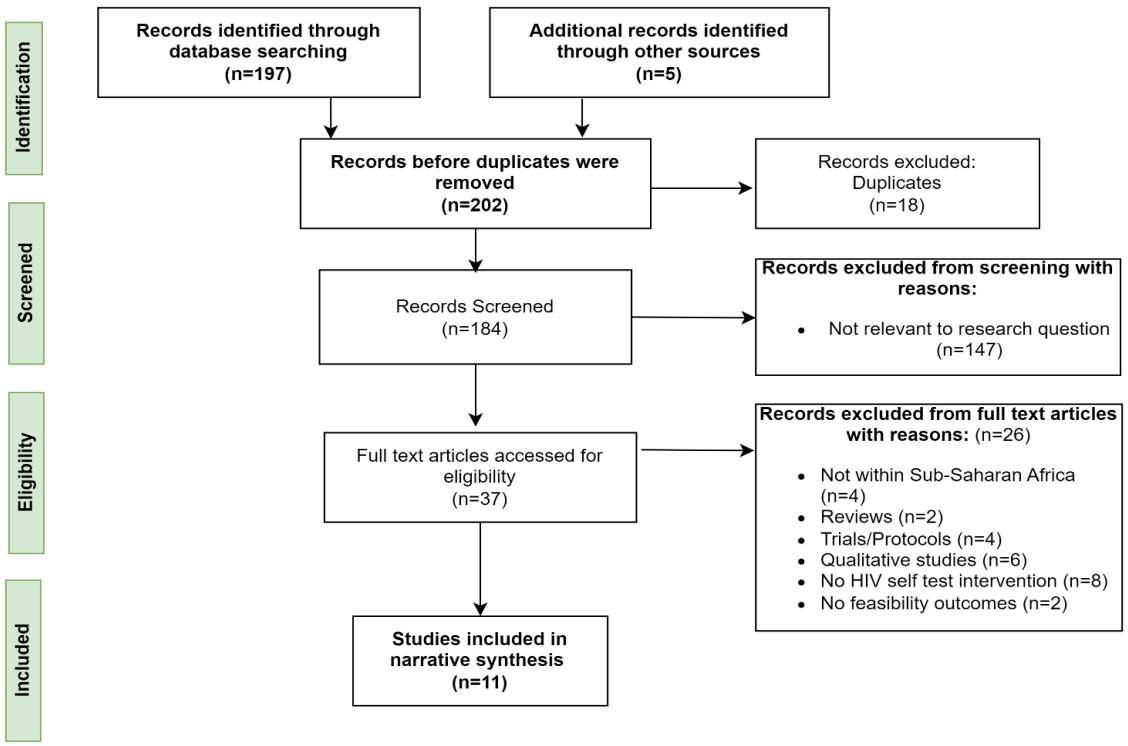

Figure 1. Flowchart of the study selection process

A. Study characteristics

In terms of geographical location, slightly over half of the studies (54%; 6/11) were conducted in South Africa, 27% (3/11) in Kenya, 9% (1/11) in Uganda, and 9% (1/11) in Malawi. By study design, observational studies [cross-sectional (6) and cohort studies (1)] made up the majority (63%, 7/11), with RCTs coming in second (36%, 4/11). Almost all observational studies (86%; 6/7) were

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also pilot studies and consequently had small sample sizes ranging from 95 to 2267. The study populations were, the general population in 54% (6/11), antenatal care clinic attendees in 18% (2/11), female sex workers (FSWs), male truckers, and health care workers (HCWs) in 9% (1/11).

B. MHealth interventions for HIVST support

Reviewed studies used SMS, phone calls, mobile apps, or a combination of two or more mHealth interventions to support HIVST. While app-based interventions were mostly used (36.4%), HIVST with a combination of mHealth (SMS, phone call, or apps) or SMS alone were evaluated individually in 27.3% of studies and phone call-based interventions were the least used (9%) (Figure 2).

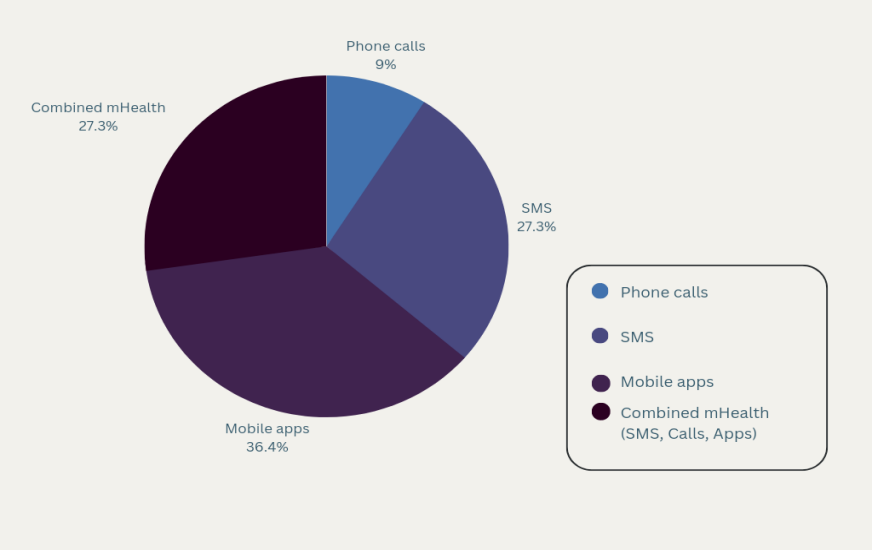

Figure 2. HIVST with mHealth intervention distribution

C. Reported metrics within feasibility

Several metrics, including HIV self-test uptake, retention on mHealth, response rate, error rates, assisted testing request rates, and supervised self-testing choice rates, were used to report feasibility. Most studies reported one or more feasibility metrics and HIVST uptake was the most common way (81.0%) of assessing feasibility. HIVST uptake was highest in app-based interventions (89.0-100.0%), 20.3-99.2% in combined mHealth interventions (SMS, phone call, or app), 22.3% in phone call-based interventions, and 4.1% to 15.9% in SMS-based interventions. Fewer studies reported other feasibility metrics such as response rates (45.0%), retention in mHealth (18.0%), assistance rate (18.0%), supervised rate (18.0%), and error rates (9.0%). Linkage to care using mHealth was also reported in 45.0% of studies.

Feasibility metrics were inconsistently reported because definitions varied across studies. For example, one study defined retention rate on mHealth as the proportion of participants that completed the post-test survey (42), while another defined it as the proportion of participants retained at 1 and 3-month assessment time points (29). The heterogeneity in reported metrics therefore posed a challenge with results cohesion and precluded the pooling of a meta-analysis across studies.

D. Narrative syntheses

SMS-based interventions: Two of the three studies that used SMS-based interventions found statistically significant increases in HIVST uptake among FSWs [15.9% intervention vs. 6.1% controls, p = 0.001] (43) and male truckers [4.1% intervention vs. 1.3% controls, p = 0.002] (31). Both studies were RCTs carried out in Kenya to investigate whether informing irregular HIV testers about the availability of HIV self-test kits using three text message reminders, spaced one week apart would increase their HIV testing rates. Although both studies concluded that SMS-based interventions can promote HIV testing uptake among populations that are hard to reach, both the truckers and FSWs had very low testing rates (4.1% and 15.9%, respectively). Of note also was that most participants (70.0%–72.2%) opted for clinic-based HIVST which was supervised, while a few others (15.0%–66.7%) who tested at home requested assistance.

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In contrast to HIVST uptake rates that was reported in the RCTs, Drake et al. (44) in a cohort study that assessed the use of SMS to report male partner HIVST results among Kenyan women seeking pregnancy-related health services (N = 486) reported feasibility as the response rate that can be attributed to SMS-based interventions. The study showed that text messages substantially increased HIVST results collection for women who had scheduled follow-up visits (RR = 1.48, 95%, [CI 1.32–1.64]), in addition to 82 (94%) more reports from women who didn't. SMS responses were further reported to have captured 68.5% (102/149) of all the HIVST outcomes evaluated for women in the survey, indicating a well above-average feasibility on HIVST outcomes. The study concluded that women who sought reproductive health services were willing and able to disclose sensitive HIVST outcomes via SMS.

App-based interventions: Selection biases resulting from the use of non-randomized control trial designs limited the four studies (5,21,42,45) that evaluated mobile app-based interventions. Three out of the four studies employed HIVST-specific apps that were designed specifically for the studies. Only one study utilized an existing mobile app (Telegram) infused with a chatbot (Nolwazi_bot). All studies used the apps to guide participants through the testing process and result interpretation using picture or video-aided information. The apps also provided a platform for self-reporting the HIVST results. HIVST uptake was high (89.0%–100%) across most app-supported mHealth studies in persons aged 18 years or older, within or outside clinic settings (5,21,45).

The study by Gous et al. (21) conducted among adults (N= 300) in South Africa demonstrated that most participants accurately completed HIVST (267; 89.0%) and captured all their information on the HIVST-specific app (210; 78.7%). Notably, few participants (26; 8.7%) had trouble using the app-based instructions for self-testing and submitting the test picture. Participants suggested multimedia supplements, more languages, simplified instructions, and a minimally sized app to make the app easier to use. Another study in South Africa showed that when mHealth supported HIVST was used, the healthcare facility recorded a 25% increase in HIV testing among clinic attendees compared to the pre-mHealth supported HIVST study period (14.5% vs 19.9%; P < 0.001) (45). Apart from the high HIVST uptake reported in most app-supported studies, the study that utilized a non-HIVST-specific app infused with a chatbot (5) reported that majority of the participants (95; 79.2%) said their experience while testing for HIV under a chatbot guidance was significantly better than it was with a human counselor. Additionally, all 21 (17.5%) participants from the non-HIVST-specific app study, who self-tested positive for HIV were referred for confirmatory HIV testing and care through the app.

In contrast, Fischer et al. (42), in another study conducted among individuals who were unlikely to self-seek HIV testing from traditional facility-based testing (N = 751), found that although most participants (70.7%) were able to log into the HIV-specific app, below average received pre-test counseling (39.3%) or self-reported their HIVST results via the app (22.4%). Some participants mentioned data expenses, difficulty uploading results, and language barriers as challenges. Among the very few participants who completed the post-test survey (5.4%), the retention rate on the app was high (95.1%; 39/41).

Phone call-based intervention: With respect to call-based interventions supporting HIVST, only one study investigated its feasibility, and it reported significant increase in HIVST uptake. The multi-arm RCT conducted in Malawi (46) assessed the effect of HIVST alone or in combination with other interventions such as call reminders or financial incentives on the uptake of HIVST and linkage to care or prevention among male partners of antenatal care clinic attendees (N = 2,349).

Relative to the conventional HIV testing study arm (13.0%), partner-delivered HIVST plus phone reminders increased the odds of men's testing for HIVST and of their linkage to care or prevention significantly (22.3%, aRR 1.58 [95% CI 1.07–2.33], p = 0.021), while no such significant increase was observed in the HIVST alone arm (17.5%, aRR 1.45 [95% CI 0.99–2.13], p = 0.130). Higher proportions of participants were also retained at 4-weeks follow up in the call reminder arm (89.6%) than in the HIVST alone (82.4%) or conventional HIV arms (80.7%). In contrast, relative to the conventional HIV testing study arm (3/3; 100.0%) and HIVST alone arm (10/11; 90.9%); fewer proportions of seropositive persons (2; 66.7%) in the HIVST plus phone reminder arm initiated antiretroviral therapy (ART).

Combined mHealth Strategies: Three studies used combined mHealth strategies (SMS, app, and call). They harnessed the strength of multiple mHealth platforms to support users with information on HIVST usage, result interpretation, platforms for reporting test results, and, in some cases, real-time help for ordering HIVST kits. Feasibility was reported as HIVST uptake and was found to be high at 78.9%–99.2% in the observational studies (29,47) but low in the RCT (20.3%) (48).

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In a cross-sectional study conducted among at-risk Ugandan adults (N = 95) who were engaged in a three month HIVST engagement project (HiSTEP), which consisted of text messages, a telehealth center, and a self-test kit (29), HIVST uptake was 78.9% by the 3-month assessment. Furthermore, retention on mHealth was higher (94%) at 3-month time points relative to 1-month (66%) time points, indicating good feasibility. While the use of a combined mHealth approach was feasible in this population, follow-up calls conducted 2 weeks after ordering HIVST to determine kit usage and test results of participants may have influenced higher levels of retention at the 3-month assessment time points relative to 1-month. Only one participant tested positive for HIV and he was linked to care (100%) successfully via the mHealth platform.

Similarly, of 251 health care workers (HCWs) in an unsupervised but synergized strategy that used the internet, public health counselors, and mobile phones in South Africa (47), most participants (99.2%) completed HIVST conduct and interpretation successfully. Of those, nine were found to be seropositive after confirmatory tests and were linked to care through mobile phones and confidential text messaging within 24 hours. While combined mHealth strategies were highly feasible to promote HIVST and facilitated linkage to care by HCWs, the fact that this population is better informed about the consequences of their health choices may have contributed to the study's feasibility. Unlike most participants (91.2%; 229/251) rating of the mHealth supported HIVST as beneficial because of the privacy it offered, when it came to counselling, the majority of participants preferred face-to-face counseling (68.4%, 160/234) over technology-enabled counseling (40.6%, 95/234).

Contrary to the high feasibility reported in the observational studies above, Phatsoane Gaven et al. (48), in a pilot RCT that assessed the utility of SMS prompts or calls to encourage self-reporting of HIVST results and linkage into care among seropositive testers, reported low self-reporting of HIVST uptake (25.3%). Nonetheless, most respondents (64.9%; 204/314) who reported a positive HIV result reported linkage or intention to link to care, using the mHealth platforms. Of note however, was that voice calls resulted in 1.9 times more responses regarding HIVST usage and 2.2 times more self-reported HIV statuses compared to SMS. The authors concluded that although the study provided evidence that combined mHealth strategies could facilitate engagement and communication with HIVST users, the low self-reporting of HIVST results observed with SMS and voice calls in this study necessitates the need for future studies evaluating which mHealth tools are better suited to self-report HIVST outcomes for these adult participants.

E. Assessment of study quality

The summary of Cochrane risk of bias is presented in Figure 3. Majority of the RCTs adequately addressed incomplete outcome data, and selective reporting. Performance and detection bias were however high because blinding of participants and outcome assessments were not clearly described. There was also knowledge of the allocated interventions by participants or outcome accessors in almost all studies. The evaluation of observational studies quality, assessed using the Newcastle-Ottawa Scale, is detailed in Table I, and scores ranged from 4 to 6.

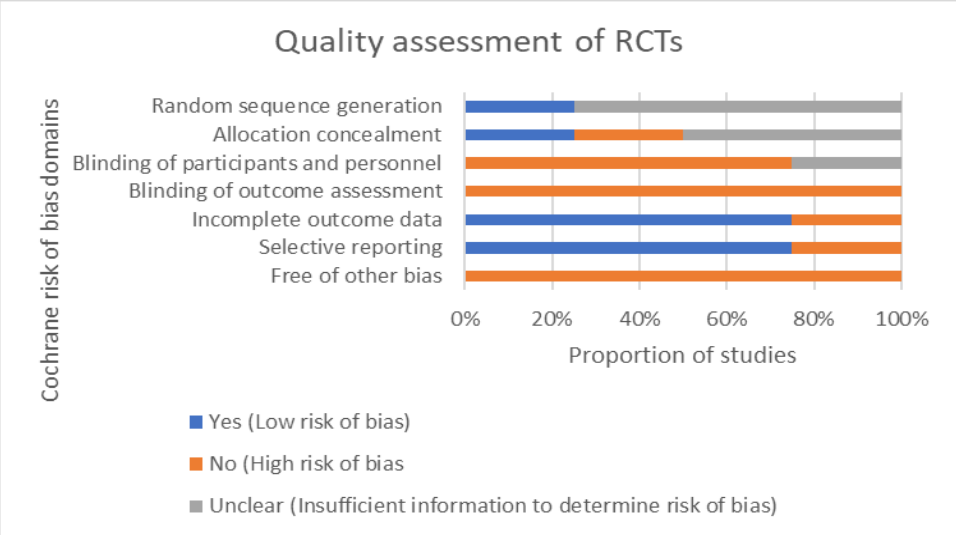

Figure 3. Quality assessment of Randomized Control Trials

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Table I: Quality Assessment of Methodological Rigor and Risk of Bias of Observational Studies in the Systematic Review of Mhealth Intervention Towards Promoting HIV Self-Testing Within Sub-Saharan Africa

Newcastle-Ottawa scale for cohort study									
First Author, Year, [Ref#]	***Selection***				***Comparability***	***Outcome***			***Total (9⋆)***
	Representativeness of exposed cohort (⋆)	Selection of non-exposed cohort (⋆)	Ascertainment of exposure (⋆)	Demonstration that outcome of interest was not present at start of study	Comparability (⋆⋆)	Assessment of outcome (⋆)	Was follow-up long enough for outcomes to occur	Adequacy of follow up (⋆)	
Drake et al., (2020) (44)	*	*	*	-	- -	*	*	*	⋆ ⋆ ⋆ ⋆ ⋆ ⋆ (6)
Modified Newcastle-Ottawa scale for cross-sectional studies									
	Representativeness of the sample (⋆)	Sample size (⋆)	Non-respondents (⋆)	Ascertainment of the exposure (risk factor (⋆⋆)	Controls for confounder (⋆⋆)	Assessment of the outcome (⋆⋆)		Statistical test (⋆)	**Total (10⋆)**
Gous et al., (2020) (21)	-	-	*	*	- -	**		-	⋆ ⋆ ⋆ ⋆ (4)
Fischer et al., (2021) (42)	*	-	*	*	- -	**		-	⋆ ⋆ ⋆ ⋆ ⋆ (5)
N. P. Pai et al., (2013) (47)	-	*	*	*	- -	**		-	⋆ ⋆ ⋆ ⋆ ⋆ (5)
Horvath et al., (2021) (29)	-	-	*	*	- -	**		*	⋆ ⋆ ⋆ ⋆ ⋆ (5)
Ntinga et al., (2022) (5)	-	-	*	*	- -	**		-	⋆ ⋆ ⋆ ⋆ (4)
Mshweshwe-Pakela et al., (2022) (45)	-	-	-	-	-	-		-	(0)

(⋆) =(yes); (-) = (No)

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IV. DISCUSSION

Although there has been a significant increase in the use of mHealth strategies, this review identified only 11 empirical studies that evaluated the feasibility of mHealth interventions aimed at promoting HIV self-testing uptake within sub-Saharan Africa. Of the studies identified, a wide range of mHealth interventions were employed, including mobile applications, SMS, calls, and combined mHealth approaches. Heterogeneity in the types of mHealth interventions and in how feasibility metrics were reported, made direct comparison of studies and robust critical evaluation across the different mHealth interventions challenging. This was however not surprising as some of the studies reviewed had reported that there were no validated universal measures for determining and subsequently reporting the feasibility of mHealth for HIVST (5,21).

There was also limited published research that specifically focused on populations in sub-Saharan Africa who are disproportionately affected by HIV (31,43)**.** Furthermore, there were geographical gaps in the distribution of these studies, with half of them (50%) conducted in South Africa, thereby limiting the generalizability of the results to other regions within SSA. Additionally, there were methodological gaps in the studies, as most of them were observational pilot studies with small sample sizes. with most studies being observational pilot studies and with small sample sizes, thereby limiting the quality of the available evidence. This limitation impairs the overall quality of the available evidence. Furthermore, despite the ubiquitous presence and acceptability of readily available and commonly inherent phone apps such as WhatsApp (49), their use and effectiveness in promoting HIVST uptake in SSA are yet to be largely explored because HIVST-specific apps were mostly reported as being used in reviewed articles (21,42).

Evidence concerning the advantages of mHealth-supported HIV self-testing in sub-Saharan Africa was reported in nearly all the studies. According to some authors, mHealth was a feasible way of notifying individuals about the availability of HIV self-testing (31,43). MHealth also supported HIVST by providing information for HIVST use, support through the testing process, afforded confidentiality and privacy through unsupervised self-testing strategy, provided a platform for reporting test outcomes, upload pictures of HIVST results and increased HIVST uptak**e** (5,21,42,45).

Specifically, when SMS were used to support HIVST, there was evidence that SMS was effective in reporting the results of HIV self-testing. As a result, SMS may provide an appropriate platform to report HIVST outcomes that happen at home, which may lessen the burden and constraints of the health system associated with in-person visits (44). Although the feasibility of SMS to self-report HIV outcomes affirms previous research (50), the main limitation of SMS-based interventions is reliance on self-reported information because it can be influenced by social desirability bias particularly if there are no built-in checks to verify reported outcomes. Additionally, the review also provided evidence of significantly increased HIVST uptake following SMS notifications (31,43). However, the low proportion of HIVST uptake reported in the intervention arm across the studies (4.1%–15.9%), which may have resulted from the deliberate selection of individuals who seldom test for HIV, hampers the feasibility of this approach. Of note, however, is that the finding of small effects with simple SMS-based reminders aligns with results of a previous systematic review (27). These findings may not be unconnected to the limitations of SMS, such as character limits.

Furthermore, in the SMS-based intervention studies, it appeared that self-testers had less confidence in their self-efficacy to self-test because more participants opted for clinic-based self-testing with supervision, and of those who chose home use, above average still requested assistance with self-testing. This might indicate that although SMS-based mHealth interventions can be a valuable means to enlighten people about HIVST and subsequently increase its demand, they are not sufficient to support users through self-testing; hence, they may not represent the ideal mHealth strategy needed to promote testing uptake among hard-to-reach populations like male truckers and FSWs. To further promote HIVST uptake, authors suggested that future studies might explore whether providing participants with resources such as videos reiterating HIVST instructions and guidance, through a combination of SMS and other mHealth platforms that support multimedia messaging, leads to increased HIVST uptake.

Regarding studies that were mobile app-based, the lack of systematically assigned comparator groups in all the studies precluded determining if the high HIVST uptake observed in most studies resulted from the intervention or other contextual variables. Nonetheless, reviewed articles provided evidence that mobile apps may be a feasible way to provide counseling, information for HIVST use, prompt users to self-report test results, and upload pictures of HIVST results for confirmation to limit social desirability bias (5,21,42,45). This was because mobile apps supported adult participants through pretest counseling and offered a discreet option of learning to self-testers through the provision of picture-assisted self-test information for use (21,45) or along with video

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demonstrations (5,42). These resources subsequently aided in the self-administration of HIVST and the interpretation of results outside of healthcare settings. App-based interventions also boosted user engagement with gamification (42). The use of a mobile app as a support component for HIVST provided users outside of clinical settings the option of unsupervised HIV self-testing, which afforded users privacy without sacrificing access to relevant HIVST information that can boost testers self-efficacy. When mHealth was further used to support HIVST within clinical settings, it resulted in an almost twofold increase in the diagnosis of HIV among individuals aged 18-35 (45). These possibilities offered by app-based interventions may make them particularly suitable for promoting HIVST among populations that are challenging to access (51).

Additionally, mobile apps enabled the collection of HIV self-testing data into a central database for monitoring and evaluation (21). Furthermore, errors reported by some participants while using the HIVST-specific apps and users suggestions provided key insights into desired areas of improvement by app users. Areas where improvements were desired were with multimedia supplements, additional languages, simplified instructions for use, data costs, and reducing the mobile app size. The review evidence implied that users were accepting of HIVST-specific apps if they were cost-effective, minimally sized, of low-literacy technology, and multimedia-aided. Although the only non-HIVST specific app (telegram) that was evaluated reported 100% HIVST uptake when supported with a chatbot, the small sample size used hampers the generalizability of the study findings (5). Participant attrition while using app-based platforms, might also be a concern. This is because one app-based study (42) reported a low retention rate of 5.5% (41/751) for participants who completed a post-test survey.

When combined mHealth strategies were used, they demonstrated high HIVST uptake (78.9%–99.2%) (29,47) and above-average (64.9%–100%) linkage to confirmatory tests and care for participants (47,48). Of note, however, was that one of the two studies that reported a high HIVST uptake incorporated a non-mHealth add-in of in-person self-testing assistance. The non-mHealth add-in may have influenced HIVST uptake, but the study's use of an observational study design precluded the comparative evaluation of the effect of the non-mHealth add-in on the reported HIVST uptake (47). Conversely, this review's findings indicate that less is known regarding the most effective combined mHealth strategies to promote HIVST uptake. As more studies using combined mHealth interventions emerge, it will be critical to use rigorous study designs that can satisfactorily establish causality as this is essential to wholly assess the feasibility and effect of combined mHealth strategies on HIVST uptake.

The only call-based intervention significantly increased HIVST uptake relative to conventional HIV testing and HIVST study arms in a RCT (46), but the low proportion of observed HIVST uptake (22.3%) raises concerns about the adequacy of phone call reminders as the ideal strategy for male partners of antenatal clinic attendees. The cost-effectiveness of phone-based interventions is also an important factor to consider especially in resource-constrained environments like low- and middle-income countries where HIV prevalence is high.

Concerning the linkage of HIV self-testers who had a positive HIVST result to care, while 7 of the 11 reviewed articles reported on linkage, only 5 used mHealth platforms to link HIV self-testers to care. The reported linkage rates via mHealth platforms varied between 64.9% and 100% across the studies (5,29,46–48). Notably, mobile apps and combined mHealth platforms demonstrated promising potential for achieving linkage to care, as they mostly reported 100% linkage for participants. Interestingly, studies that exclusively employed SMS as the mHealth platform did not report linkage to care for individuals who self-tested positive despite linkage to care being a crucial part of the HIVST approach (52). Additionally, in the two studies (46,48) that employed experimental study designs and reported on linkage, it was not stated if mHealth significantly improved linkage to care for persons whose self-test results were positive for HIV in the mHealth intervention group relative to control groups. This leaves a knowledge gap as to the effect of mHealth on linkage to care. Of note was the reporting of linkage to care varied among the studies as it included different aspects, such as referral for confirmatory testing, intention to link to care or ART initiation. Consequently, comparing the results across studies becomes challenging. Notwithstanding, the limited evidence about the impact of mHealth on linkage to care for HIVST in SSA, the available information suggests that mHealth may be a viable option to support the utilization of HIVST in the region.

V. POTENTIAL DIRECTIONS FOR FUTURE RESEARCH

More studies within each category of mobile technology domain are recommended to allow for critical evaluation of the literature within each mHealth type, which will guide the successful planning and implementation of future HIV self-testing programs by

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relevant stakeholders. Specifically, future app-based research should also prioritize higher-quality studies such as RCTs with a larger sample size, and conducted among diverse populations to provide more evidence of mobile apps feasibility in promoting HIVST uptake in SSA. Future studies may also benefit from research targeted at improving participant retention on mobile apps to limit the high attrition rate of participants reported in one of the app-based studies. Also, when HIVST-specific app is the intervention choice, stakeholders should invest in the development of minimally sized, user-friendly, culturally appropriate, and cost-effective apps. The apps should also require low literacy, allow for multimedia incorporation, additional languages, and simplified instructions so as to endear them to end users and ultimately promote HIV self-testing uptake. Furthermore, other readily available and commonly inherent phone apps with which most people are already familiar, such as WhatsApp, should be used and evaluated for their feasibility in promoting HIVST uptake in sub-Saharan Africa.

Although SMS and phone calls significantly improved HIVST uptake, comparative studies evaluating their effectiveness and cost effectiveness against other mHealth, such as apps, need further investigation. Future studies would benefit from larger sample sizes because the small sample sizes used in the majority of the reviewed articles limit the generalizability of the study findings. It is also recommended that more primary studies be carried out in key populations, such as Men who have Sex with Men or Female Sex Workers, whose prevalence of HIV is higher (17,53) and are unlikely to seek facility-based HIV testing (51). We also recommended that more primary research be conducted in more countries within the SSA sub-region so as to evaluate which mHealth support strategies for HIVST are best suited within these localities. Concerning linkage to care, future research should explore the most efficient mHealth platforms suitable for linkage to care following HIVST kits usage by target populations. Lastly, future studies should invest in a review of relevant literature to develop uniform indicators for reporting and evaluating the feasibility metrics for mHealth interventions in order to reduce heterogeneity in reporting feasibility outcomes.

VI. LIMITATIONS

As the evidence in this review spans mHealth-supported HIVST interventions written in English, the review may have excluded some relevant articles not written in English. Additionally, as only quantitative studies were included in the review, relevant information contained in qualitative studies may have been missed. The review was also confined to studies conducted within SSA, and study recommendations may not be generalizable globally. Also, these review results are only up to date as of March 2023. Despite these limitations, the researcher believes that the depth of evidence presented here summarizes existing endeavors that utilize mHealth to promote HIVST in SSA and their feasibility while also providing key insights into priority areas for future research on HIVST within this African sub-region.

VII. CONCLUSION

This systematic review synthesized evidence that summarizes existing published literature on the feasibility of utilizing mHealth to promote HIVST uptake in SSA. The volume of evidence presented regarding the utilization of mobile health for HIVST support in sub-Saharan Africa is an indication of growing interest in the potential that mobile phones offer towards improving access to and support for HIVST in low-resource settings. This systematic review reveals that mHealth supported HIV self-testing in various ways within and outside clinical settings through guidance for use, a platform for getting assistance with testing, self-reporting of self or partner results, linkage to confirmatory tests, and prompts for follow-up. Although different types of mHealth interventions were used to promote HIVST in various settings and study populations, this review demonstrates variable feasibility of the diverse mHealth (SMS, calls, apps, or combined mHealth) strategies to promote HIVST. More research is needed to investigate inconsistencies in feasibility results and determine the most feasible and efficient mHealth supported HIVST promotion strategies. Several evidence gaps also need to be addressed, including the need for more high-quality RCTs, studies that target key populations and are conducted in diverse sub-Saharan African countries. The exploration of the use of readily available and common mobile apps for mHealth interventions, as well as uniform indicators for reporting of feasibility metrics for mHealth interventions in order to standardize their reporting across all studies also need to be considered.

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ETHICAL CONSIDERATION

All ethical procedures were followed.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

DATA SHARING STATEMENT

The information presented in this research has been derived from previously published original data. The data underpinning the conclusions of this study can be accessed in Supplementary Tables I and II.

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SUPPLEMENTARY TABLES

Table I: Characteristics of Studies That Assessed Mhealth Interventions Towards Promoting HIV Self-Testing Within Sub-Saharan

Author, Year, [#Ref]	Geographical location	Study design	Study population/sample size	Study period	Type of HIVST mHealth component	Non mHealth add on
Gous et al., (2020) (21)	South Africa	Cross-sectional study (PILOT)	Convenience sample of 300 consenting persons aged 18 years or older in a high prevalence setting, who own a mobile phone and are able to read English(N=300)	July 2018	Mobile app (AspectTM App)	Trained HCWs observed participants and documented any deviations from the provided instructions on how to perform the test.

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Drake et al., (2020) (44)	Kenya	Cohort Study	HIV-negative women who accepted HIVST, were aged 14 years or older seeking antenatal, postpartum, or family planning services and with a male partner and access to a phone that supports Safaricom SIM (N=486 women)	November 20, 2017, to June 15, 2018,	SMS	NR
Fischer et al., (2021) (42)	South Africa	Cross-sectional study (PILOT)	Randomly selected adults from the general populace, with an unknown HIV sero-status, who have not undergone HIV testing in the previous three months, willing to perform an HIVST and with access to a smartphone that supports Ithaka app (N=751)	November 2018 to June 2019	Mobile app (Ithaka)	NA
Kelvin, George, Kinyanjui, et al., (2019)a (31)	Kenya	Randomized controlled trial	A random sample of male truckers who were HIV-negative, had not undergone HIV testing within the prior three months, and had received less than four HIV tests in the previous year (N=2262)	December 2016	SMS	NA
Kelvin, George, Mwai, et al., (2019)b (43)	Kenya	Randomized controlled trial	Random sample of HIV-negative FSW who had not undergone HIV testing within the prior three months and had received less than four HIV tests in the previous year (N=2196)	Feb-March 2017	SMS	NA

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N. P. Pai et al., (2013) (47)	South Africa	Cross Sectional Study (PILOT)	A convenient sample of healthcare workers (HCWs) aged 18 years or older and have an unknown HIV status (N=251)	January and June 2012,	Mobile phone call and SMS	An HIV self-test application, accessible via the internet or in print, designed to support the HIVST users with information on usage, interpretation and linkage Face-to-face assistance with HIVST provided by public health counsellors if desired
Horvath et al., (2021) (29)	Uganda	Cross-sectional study (PILOT)	Persons 18 years old and above who were negative for HIV or had an unknown HIV status, engaged in unprotected sex within the previous three months, and possessed or had the means to use a mobile phone. (N=95)	April to July, 2019,	SMS, mobile app (Facebook messenger, Twitter), phone call and telehealth center	NA
Phatsoane Gaven et al., (2023) (48)	South Africa	Randomized control trial (PILOT)	Individuals aged 18 and older, possessing a mobile phone capable of receiving SMS messages, and not having undergone an HIV test in the preceding three months (N=9,505).	Not stated	SMS and phone call	NA

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Ntinga et al., (2022) (5)	South Africa	Cross-sectional study (PILOT) .	Convenience sample of consenting individuals between the ages of 18 and 47 years, who had received a HIV test administered by a human counselor at some point in their life, had an unknown HIV status and capable of smartphone usage to chat with a Chatbot (N=120)	December 2020 to April 2021.	Mobile app using a chatbot (Nolwazi_bot)	NA
Mshweshwe-Pakela et al., (2022) (45)	South Africa	Cross-sectional study (PILOT)	Convenience sample of consenting persons aged 18 years or older that had the willingness to test for HIV in either of two healthcare facilities (N=2267)	February 2019-Septembber 2019	Mobile app (Ithaka HIVST specific app)	HIVST facilitator (trained in HIV testing) that can assist clients with self-testing when called upon.
Choko et al., (2019) (46)	Malawi	Randomized control trial	A random sample of antenatal care clinic attendees who were aged 18 years or older, with a primary male partner unknown to be receiving antiretroviral treatment (N=2,349).	8 August 2016 - 30 June 2017	Phone call reminder	Option of a financial incentive, either $3 or $10. A 10% probability of receiving $30 in a lottery.

Table II: Study Description and Findings in Assessing Mhealth Interventions Towards Promoting HIV Self-Testing Within Sub-Saharan Africa

Author, Year, [#Ref]	Intervention description	Study objective	Results	Authors conclusion
Gous et al., (2020) (21)	The app allowed self-testers to enter their data, guided participants through the testing process with picture-aided self-test information, and encouraged testers to	To assess the feasibility of successful HIV self-test completion and	**HIVST uptake** -89.0% (267/300) successfully completed HIVST correctly while 78.7% (210/300) effectively recorded all required information	Mobile app is a feasible way to provide information for HIVST use, upload HIVST results and may decrease interview bias.

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	upload a photo of their HIVST result and their interpretation of the result. This facilitated manual review of result images by another individual, thereby identifying and flagging potentially discrepant results for subsequent investigation.	data capture through a mobile app.	using the designated application **Error rates** The majority (26 cases, accounting for 8.7%) of errors were HIVST usability and from the information that guided the self-testing process **Linkage to care** Regarding linkage to care, 43 participants (14.3%) were confirmed as HIV positive and subsequently referred to HCWs for further care	Mobile app allowed for collection of HIV self-testers information to a central database for M&E.
Drake et al., (2020) (44)	An automated SMS system (mSurvey) prompted women to send HIVST facilitated cost-free submission of HIVST results by women. Outcome data were gathered through SMS at 2.5 weeks, face-to-face at 1 month for individuals with scheduled follow-up, or using both methods for those on PrEP	To assess the utilization of SMS for reporting male partner HIV self-testing results and identify potential reporting biases among women with scheduled follow-up appointments compared to those without, as well as between women reporting through SMS versus face-to-face.	**Response rate** The utilization of SMS significantly increased the collection of HIVST outcomes among women with scheduled follow-up appointments, showing a notable increase of 1.48 times (RR = 1.48, 95% CI 1.32-1.64). Furthermore, it captured 82 additional reports from women who did not have scheduled follow-up visits. HIVST outcomes related to experiencing harm or negative reactions from partners due to the HIVST were significantly higher in the SMS group compared to in-person interactions (17/102, 16.7% vs 2/85, 2%; P=.003). **Linkage to care** Data was not provided for linkage to care	The utilization of SMS significantly enhanced the comprehensiveness of outcome data collection without introducing bias in reporting non-sensitive information. Additionally, it may encourage increased reporting of sensitive information. Female individuals accessing reproductive health services demonstrated both willingness and capability in utilizing SMS to respond to surveys concerning sensitive HIVST outcomes related to their male partners.

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Fischer et al., (2021) (42)	Participants were provided app access, which tracked when users logged-on, supported users through pretest counselling, how-to-test instructions, self-reporting of results, and boosted user engagement with gamification. Users had the convenience of testing at home and self-reporting results via the app at their convenience Data was gotten from in-person pre-study survey, the Ithaka platform and a telephone post-study feedback survey.	To evaluate the use of a secure app designed to self-report results of HIVST while its provider-billed.	**Response rate** In a study involving 751 participants, 70.7% logged onto the application, 295 (39.3%) received how-to-test instructions and pretest counselling while only 168 (22.4%) self-reported results. **Retention rate** Among participants who completed baseline surveys, only 5.5% (41/751) finished post-test surveys, but of these, 95.1% claimed usage of the application to completion. **Linkage to care** 8.3% (14/168) of participants tested HIV positive but data was not provided for linkage to care	HIVST users in non-clinical settings demonstrated both the willingness and capability to self-report their test outcomes through the application.
Kelvin, George, Kinyanjui, et al., (2019)a (31)	Notifying male truckers about HIVST availability using three SMS reminders delivered one week apart in the intervention group compared to control groups who received SMS about general HIV testing availability. Male truckers were randomized to one of three study group and participants were followed up for two months post-receipt of the first SMS to evaluate their HIV testing	To evaluate whether notifying male truck drivers who infrequently undergo HIV testing about HIVST availability would enhance their rates of HIV testing	**HIVST uptake** HIVST uptake was significantly more in the SMS plus HIVST group compared to the control group (31 vs. 10, p = 0.002) but self-testing rates were very low (4.1%) despite the dissemination of text messages regarding the availability of HIV self-test kits. **Supervised HIVST choice** 70.0% (14/20) of testers opted to conduct the self-test in a clinic setting under supervision. **Assisted HIVST choice** Of those who chose home use, 66.7% (4/6) called for assistance when testing while 50.0% (3/6) requested counseling after	Announcing HIVST availability through text messaging resulted in heightened HIV testing rates among truckers, however, the low testing rate observed indicates that SMS can only partially increase HIV Testing rates among truckers

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			the testing, with two individuals seeking counselling both during and after the testing. **Linkage to care** 5 participants tested HIV positive but data was not provided for linkage to care	
Kelvin, George, Mwai, et al., (2019)b (43)	Notifying female sex workers about HIVST availability using three SMS reminders delivered one week apart in the intervention group compared to control groups who received SMS about general HIV testing availability. Female sex workers were randomized to one of three study group and participants were followed up for two months post-receipt of the first SMS to evaluate their HIV testing.	To evaluate whether notifying female sex workers who infrequently undergo HIV testing about HIVST availability would enhance their rates of HIV testing	**HIVST uptake** HIVST uptake was significantly more in the SMS plus HIVST group compared to the control group (119 vs. 46, p = (p<0.001) but self-testing rates were very low (15.9%) despite the dissemination of text messages regarding the availability of HIV self-test kits **Supervised HIVST choice** 72.2% (n=52/72) of testers opted to conduct the self-test in a clinic setting under supervision. **Assisted HIVST choice** Of those who chose home use, 25.0% (5/20) called for assistance while testing 3/20 (15 .0%) requested counseling after the testing, and 35.0% (7/20) sought counselling during and after the testing. **Linkage to care** 5 participants tested HIV positive but data was not provided for linkage to care	Announcing HIVST availability through text messaging resulted in heightened HIV testing rates among FSWs, however, the low testing rate observed sugests that SMS interventions only offer a partial increase in HIV testing rates among FSWs.

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N. P. Pai et al., (2013) (47)	An unsupervised, self-testing strategy consisting of oral HIVST kit, access to the Internet or paper-based HIVST app and mobile phones was given to participant and evaluated for feasibility. Participants were offered assistance either through phone support or in-person guidance based on their preference. Confidential post-test counseling and treatment linkage were facilitated through telephone communication with counselors.	To evaluate for mHealth feasibility; defined as completion of self-testing process (i.e., self-test conduct, interpretation and linkage). ..... To assess the feasibility of mHealth, defined as the successful execution of the self-testing process (including self-test conduct, interpretation, and linkage	**HIVST uptake** HIVST was successfully completed and interpreted by 99.2% (249 out of 251) of study participants. **Linkage to care** 9 participants were sero-positive and linked to care within 24 hours achieving a 100% completion rate (95% CI, 66.0–100) via mobile phones and confidential SMS. Furthermore, nearly half of the sero-negative testers received counseling via mobile phones, with a completion rate of 44.6% (95% CI, 38.0–51.0).	The implementation of an unsupervised self-testing approach proved feasible for conducting and interpreting self-tests. Additionally, confidential and effective linkages to care via phone among healthcare workers in South Africa was successfully achieved
Horvath et al., (2021) (29)	The participants received theoretically-grounded messages via a communication channel of their preference (such as SMS, Facebook Messenger, Twitter direct message). Additionally, they were granted access to a telehealth center offering real-time assistance for HIVST, along with the provision of complimentary HIV self-testing kits facilitated through a private communication channel (e.g., telephone call, SMS, Facebook Messenger)	To assess the feasibility of a 3-month HIVST Engagement Project (HiSTEP by measuring participant recruitment numbers and retention percentages at the 1 and 3-month assessment time points using mHealth	**HIVST uptake** 75 participants (78.9%) confirmed the use of HIVST **Retention rate** The study demonstrated a retention rate of 66% after one month and a notably elevated rate of 94% after three months of assessment **Linkage to care** Out of 73 participants, 1.3% tested positive for HIV through the HIV self-testing kit and was successfully linked to HIV care (100%) through the mHealth platform.	A centralized system employing diverse methods of mHealth for promoting, supporting and distributing HIVST kits could be feasible in encouraging the uptake of HIVST, especially when engaging at-risk adults.
Phatsoane Gaven et al., (2023) (48)	After providing participants with an HIVST kit, participants were randomized to receive standard or behavioral SMS reminders that encouraged those who had used the test to self-report their test usage and results.	The study evaluated the utility of a mobile-health (mHealth) platform for self-reporting of HIVST results by users and whether seropositive	**Response rate** Few participants (2,467/9,505; 26.0%) answered any HIVST question using the mHealth platforms Behavioral SMS was ineffective in increasing self-reporting of HIVST outcomes when compared to regular SMS (25.3%	While the disclosure of HIVST outcomes was low across all the used mHealth platforms, self-reporting HIVST the self-reporting of HIVST outcomes through phone calls demonstrated a higher response rate

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	By the seventh day from the study's commencement, phone calls via an interactive voice response system (IVRS) were made to participants who had not initiated contact, aiming to collect their self-test results and to gather information for linking seropositive individuals to appropriate care.	users linked into care.	intervention vs. 27.8% control, 95% CI: 0.5–2.9%, p = 0.2). Voice calls via the IVRS system resulted in 1.9 times more responses on HIVST usage and 2.2 times more self-reports of HIV status compared to SMS. **Linkage to care** Among the 314 respondents reporting a positive HIV test result, 64.9% (204/314) expressed linkage to or intention to link to care using the provided mHealth platforms. Report differentiating intervention or control groups linkage data weren't stated.	compared to the behavioral SMS approach.
Ntinga et al., (2022) (5)	A native-speaking mHealth conversational bot ran on the telegram messaging app and guided testers through conversations about importance of their readiness to self-test, link to a video demonstrating the kit's usage for persons who were ready to test and on how to interpret the result for persons who had self-tested. The need to take a picture of all self-tests results and confirm a positive self-test result was also emphasized by the bot.	The study assessed the feasibility and acceptability of a Chatbot specifically created to aid HIVST	**HIVST uptake** All participants (120/120), performed HIVST using the bot. Most participants (n=95/120, 79.2%) their HIV testing experience with the chatbot to be notably better to that with a human counselor and most (93/120, 77.5%) felt as if they were talking to a real person because of the tone and the choice of words of the bot. Some participants however said that the chatbot was not as empathic as a human counselor (11, 9.2%), that the conversation was unidirectional (5%, 6/120) and making mistakes with it was easier (4, 3.3%) **Linkage to care**	The researchers inferred that chatbots could promote HIVST due to its potential to mitigate certain barriers linked to HIVST uptake

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			17.5% (21/120) of participants tested positive and were all promptly directed by the app for confirmatory testing and subsequent care.	
Mshweshwe-Pakela et al., (2022) (45)	Participants received visual guidance via pictorial instructions, an OraQuick HIVST kit and a tablet equipped with a mobile app detailing HIVST procedures, living with HIV information, and featuring a countdown timer for the testing process. The research was facility-based in two health facilities and was conducted in HIVST booths.	The study explored the feasibility of incorporating mHealth-supported HIVST within the clinical setting, conducting a pre-and-post implementation analysis comparing HIV testing volume and the usage of HIVST.	**HIVST uptake** 2267 clients used HIVST The mHealth HIVST program led to a 25% increase in facility-based HIV tests among individuals aged 15 years and older (14.5% vs 19.9%; P < 0.001) without compromising HIV testing yield. **Linkage to care** 264/2267 (11.6%) were positive on HIVST. 241/264 (91.3%) had a confirmatory test. 230/241 (95.4%) were confirmed to be HIV-positive. Among those confirmed positive, 150 (65%) initiated antiretroviral therapy within two weeks. Linkage to care was facilitated by the trained HIVST workers.	Combining facility-based approaches with mHealth-suported HIVST holds promise for increasing HIV testing rates in high HIV prevalence clinical settings
Choko et al., (2019) (46)	Participants were allocated randomly to receive either the standard of care (SOC), comprising a clinic invitation letter to the male partner, or assigned to one of five intervention groups: the first group furnished women with 2 HIV self-testing kits for their partners; the subsequent two groups offered 2 HIVST kits alongside a conditional fixed financial incentive of either $3 or $10; the fourth group were provided 2 HIV self-test kits along with a 10% probability of obtaining $30 through a lottery; and the fifth group were supplied 2	The study evaluated the effect of HIV self-testing, either alone or when combined with other interventions, on the uptake of HIVST and the subsequent linkage to care or prevention among male partners of attendees at antenatal care clinics.	**HIVST uptake** Relative to the conventional HIV testing study arm (13.0%), higher proportions of male partners of ANC attendees in the HIVST plus phone reminder arm reported testing for HIV and linkage into care or prevention (22.3%, aRR 1.58 [95% CI 1.07–2.33], p = 0.021). However, there was no statistically significant increase in the HIVST alone arm (17.5%, aRR 1.45 [95% CI 0.99–2.13], p = 0.130)	The combination of phone call reminders with partner delivered HIVST significantly increased the odds of male partners of antenatal care attendees linking to care or prevention services

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	HIVST kits coupled with a phone call reminder for the female participants' partners.		regarding testing and linkage to care. **Linkage to care** Fewer seropositive persons (2/3; 66.7%) in the HIVST plus phone reminder arm, initiated ART, relative to the conventional HIV testing study arm (3/3; 100.0%) and HIVST alone arm (10/11; 90.9%) respectively.	

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